77075

Impact melt dike in cataclastic norite

172.4 grams

Figure 1: Front and back photos of 77075. Scale and cube are 1 cm. NASA# S73-17186 and S73-17185. These pieces were found to fit together.

Introduction

Sample 77075 was sampled from one of the dark dikes within the large, off-white "noritic" clast in the boulder at Station 7 (see the section on the Station 7 Boulder). The dike is about 3 cm thick (Chao et al. 1974), and has portions of the white clast attached on both sides. The white "noritic" material is the same as sample 77215 (figure 1). Sample 77076 and piece 19 of 77215 also appear to be identical to 77075.

The dark dike material in 77075 is a fragment-laden melt rock with a matrix texture and chemical composition generally similar to sample 77115, except it has a finer grain size (Chao et al. 1974). Schmitt (in Schmitt and Cernan, 1973) observed that the dike material was continuous with the "blue-gray, matrix-rich breccia" (represented by 77115) that surrounds the off-white "noritic" clast that the dike cuts (figures 2 and 3).

Figure 2: Closeup photo of boulder at Station 7 Apollo 17 . The vein through the off-white norite clast can be clearly seen through the brown patina. Schmitt observed that this vein (77075) is continuous with the surrounding breccia (77115) and cross-cuts the norite (77215). AS17-146-22327.

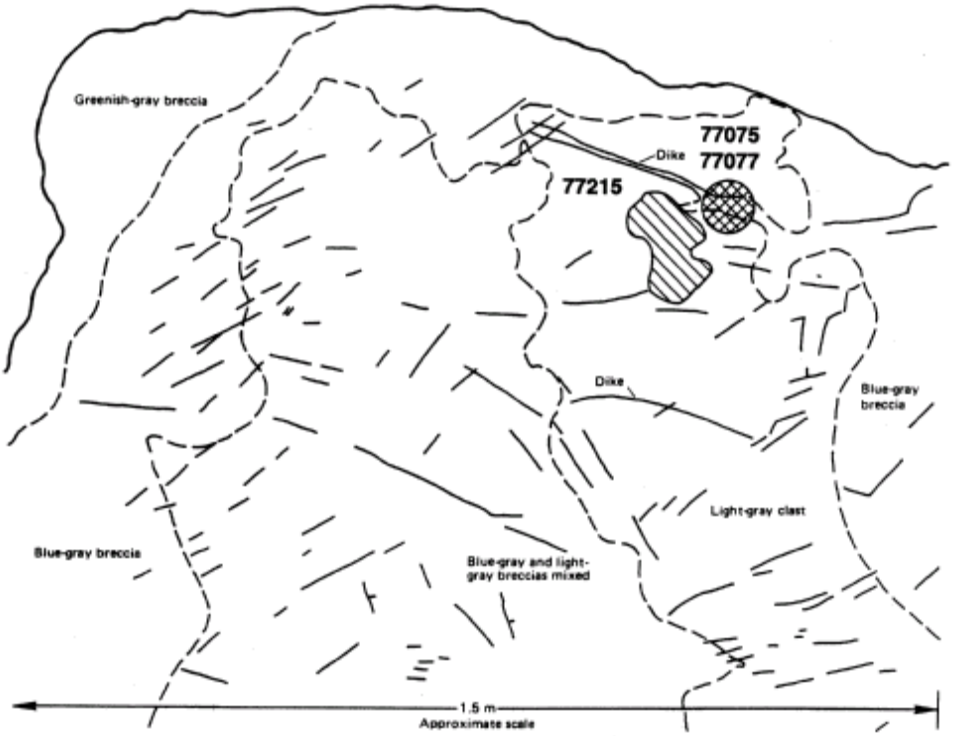

Figure 3: Sketch of north side of Station 7 Boulder, showing large norite clast (light grey clast) with penetrating veins and the location of the samples taken (from Wolfe and others, 1981).

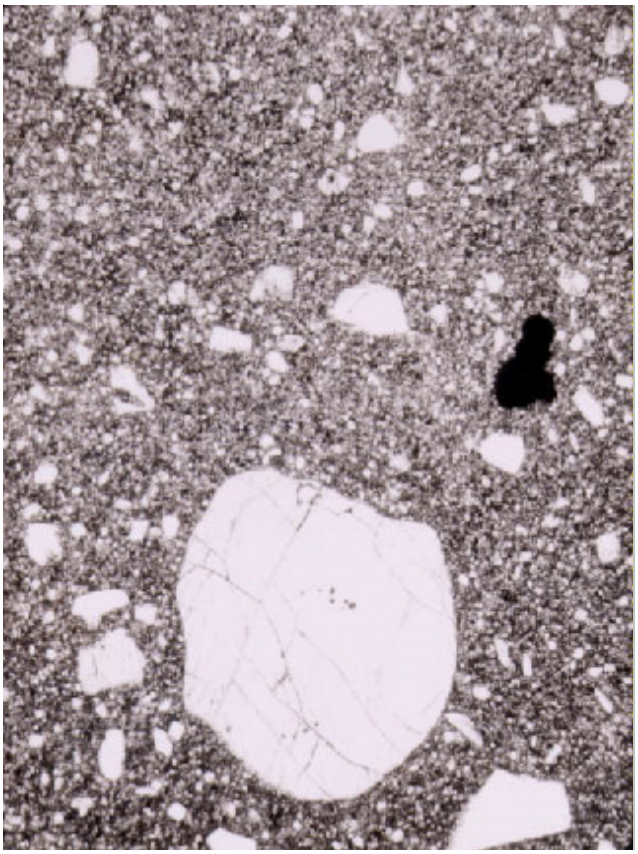

Figure 4: Photomicrograph of thin section of dark dike in 77075 showing olivine clast and other small xenoliths in a finely crystaline matrix.

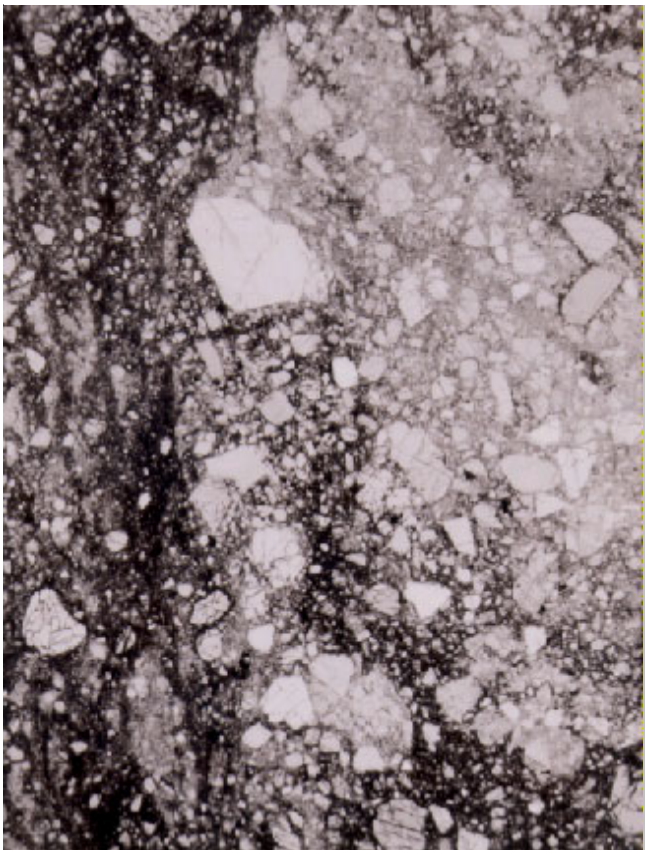

Figure 5: Photomicrograph of thin section of cataclastic norite (white material) in 77075.

This sample and others from the Station 7 boulder were studied by the International Consortium led by Ed Chao (see summary by Minkin et al. 1978). The results on 77075 were also summarized in the catalog by Meyer (1994).

Petrography

Dike rock 77075 is the finest grained, most fragment-rich lithology of the station 7 boulder (Chao et al. 1974, Minkin et al. 1978). The holocrystalline matrix is a fine-grained intergrowth of subophitic plagioclase and pyroxene, with minor olivine and ilmenite. Average grain size is 5-10 microns with poikilitic pyroxenes 10-20 microns. A few percent mineral and lithic clasts are also present (figure 4). The dense, dark dike has a sharp boundary with the porous, "noritic" microbreccia (figure 5).

Mineralogical Mode of 77075 (dark dike material)

	Chao et al. 1974	Minkin et al. 1978
Pyroxene	16.7	24 vol. %
Plagioclase	62.1	64
Olivine	16	8
Ilmenite	2.7	4
Ni-Fe	2.1	

McGee et al. (1980) conclude that the 77075 dike crystallized and cooled through the solidus more rapidly than did the enclosing lithologies 77115 and 77135. Presumably, the relatively rapid cooling of the dike also inhibited precipitation of augite. It is thought that the incorporation of cool clasts into the melt, and injection of the melt into a cooler noritic host, contributed to rapid initial cooling and the fine grain size of the dark dike material (McGee et al. 1980, Sanford and Heubner 1980).

Mineralogy

Pyroxene: The composition of pyroxene in the melt rock portion was determined by TEM (McGee et al. 1980), because it was too fine grained for accurate electron microprobe analysis (Figure 6). Augite was not seen in 77075 by microscope, but was found as 10 micron exsolution lamellae using TEM techniques. Bersch (1991) precisely determined the composition

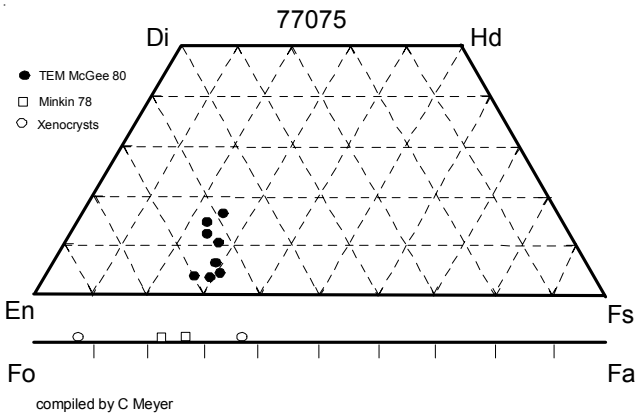

Figure 6: Pyroxene and olivine compostion of 77075 dike. Pyroxene had to be determined by TEM, because of fine grain size (~5 micron).

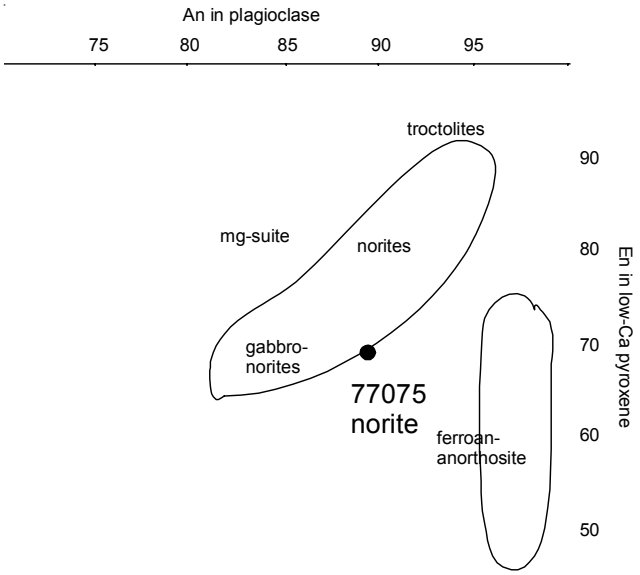

Figure 7: Plagioclase and pyroxene composition of white clast material on 77075. Data from Minkin et al. 1978.

of the orthopyroxene in the white "noritic" portion of 77075.

Plagioclase: The plagioclase in the matrix of 77075 is $An_{89\text{-}92}$, while some xenoliths of plagioclase range to An_{97} (Chao et al. 1974).

Olivine: Small xenocrysts of olivine ($Fo_{66\text{-}93}$) are found in the matrix of 77075 (Chao et al. 1974, Minkin et al. 1978).

Other minerals: Ilmenite is very fine and platy (Chao et al. 1974). Blebs of Fe-Ni are present.

Chemistry

Winzer et al. (1974) and Norman et al. (2002) have analyzed the aphanitic dark dike and Warren and Wasson (1978) analyzed the white material attached (table 1 and figure 8). The composition of the dark dike matches that of 77115 and the white material is the same crushed norite as 77215.

The trace element data of Norman et al. (2002) and that of Morgan et al. (1974) generally agree and they both report high Ir in the dike material.

Radiogenic age dating

Stettler et al. (1974, 1978) determined an age of 3.97 ± 0.04 b.y. for the dark dike (average of three measurements). Nakamura and Tatsumoto (1977) determined a Rb/Sr isochron for the dark dike (4.18 b.y.), as well as an imprecise Sm/Nd isochron (figure

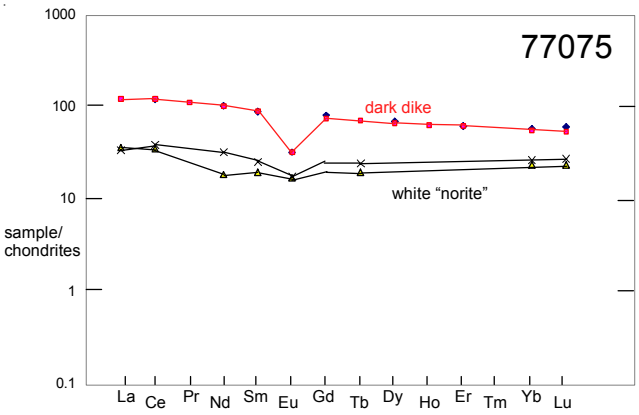

Figure 8: Normalized rare-earth-element composition diagram for 77075. Data for dark dike from Winzer et al. (1974) and Norman et al. (2002). Data for white norite is from Warren and Wasson (1978).

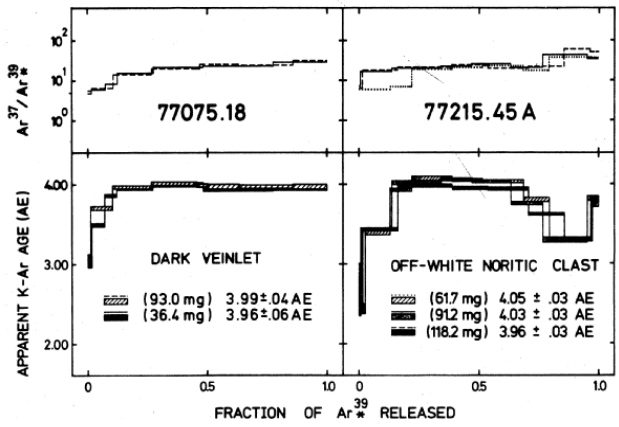

Figure 9: 40Ar/39Ar release pattern for 77075 dike material and 77215 norite (from Stettler et al. 1974).

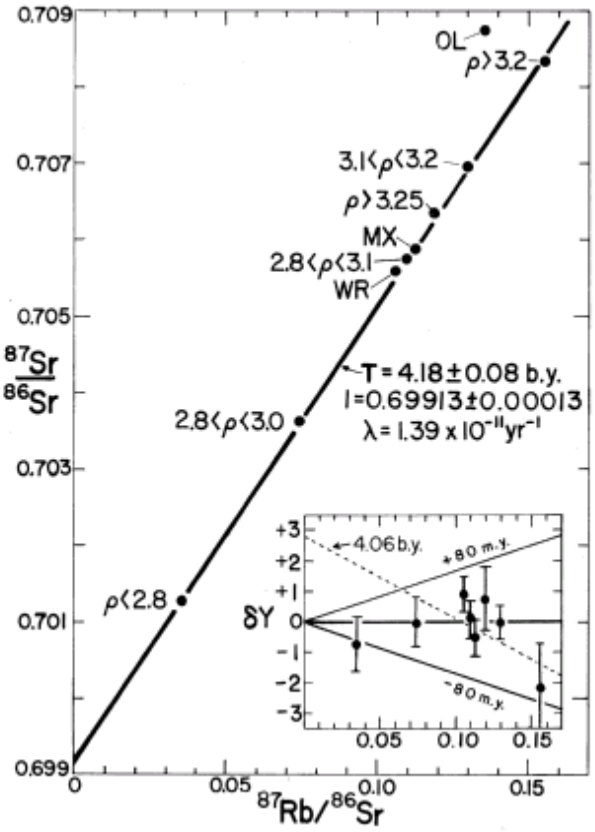

Figure 10: Internal Rb/Sr mineral isochron for 77075 dark vein material (from Nakamura and Tatsumoto 1977).

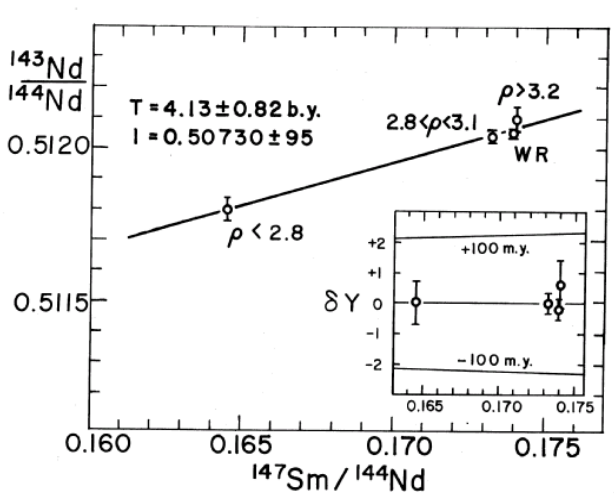

Figure 11: Imprecise Sm/Nd isochron for dark dike in 77075 (from Nakamura and Tatsumoto 1977).

11), but their sample may have included xenoliths of older material. Nunes et al. (1974) also reported U, Th, Pb data for 77075.

Cosmogenic isotopes and exposure ages

Stettler et al. (1974) obtained an exposure age of 25.5 m.y. for 77075 by the Ar method. A review of the exposure ages determined for this boulder is given in Arvidson et al. (1975).

Processing

The initial processing and distribution of 77075 is outlined in Butler and Dealing (1974). It was studied by the International Consortium led by Ed Chao (final report by Minkin et al. 1978). A detailed description of the splits was documented in USGS Open File Report 78-511.

List of Photo #s for 77075

Summary of Age Data for 77075

	Ar/Ar	Rb/Sr	Sm/Nd	U/Pb
Stettler et al. 1974	3.99 ± 0.03 b. y.			
	3.96 ± 0.08			
Stettler et al. 1978	3.98 ± 0.03			
Nakamura et al. 1977		4.18 ± 0.08	4.13 ± 0.82	
Nunes et al. 1974				

Caution: Not corrected for new decay constants.

Table 1. Chemical composition of 77075

	dark		dark		white	white		dark		77077	77215
reference	Norman 02		Winzer 74		Warren 78			Morgan 74		Warren 78	Winzer 77
weight	3 g		66 mg							*comparison*	*comparison*
SiO2 %	46	(d)	46.4	(e)	51.1	50.9	(g)			50.9	51.1
TiO2	1.52	(d)	1.38	(i)	0.34	0.35	(g)			0.3	0.3
Al2O3	17.9	(d)	18.17	(e)	14.97	14	(g)			16.16	13.98
FeO	8.99	(d)	9.31	(e)	10.67	10.16	(g)			8.74	10.38
MnO	0.12	(d)	0.11	(e)	0.17	0.18	(g)			0.15	0.17
MgO	13	(d)	12.57	(e)	12.9	13.78	(g)			10.6	14.31
CaO	10.8	(d)	10.55	(e)	8.82	8.82	(g)			9.94	8.65
Na2O	0.66	(c)	0.65	(e)	0.38	0.36	(g)			0.44	0.39
K2O	0.24	(c)	0.23	(e)	0.18	0.16	(g)			0.22	0.18
P2O5			0.26	(i)							0.14
S %											
sum											
Sc ppm	16.9	(a)			16.6	16.5	(g)			13.8	
V	44	(a)									
Cr	1354	(a)	1163	(e)							2463
Co	25.4	(a)			33	25.9	(g)			25.2	
Ni	211	(a)			6.1	<1.1	(g)	286	(h)	< 1.7	
Cu	13.5	(a)									
Zn	14.4	(a)			3.25	3.31	(g)	2.8		2.84	
Ga	5.1	(a)			4.03	4.1	(g)			5	
Ge ppb					10.9	16.8	(g)	532		18.7	
As											
Se								112			
Rb	8.9	(a)	6.1	(f)				6.4			3.21
Sr	183	(a)	165	(f)							102
Y	117	(a)									
Zr	507	(a)			210	170	(g)			150	
Nb	34.6	(a)									
Mo											
Ru	27.2	(b)									
Rh											
Pd ppb	25.9	(b)									
Ag ppb								1.2			
Cd ppb											
In ppb											
Sn ppb											
Sb ppb								1.92			
Te ppb											
Cs ppm	0.29	(a)						0.27			
Ba	327	(a)	333	(f)	160	158	(g)			220	154
La	29.1	(a)			7.2	8.3	(g)			9.9	
Ce	75.7	(a)	74.3	(f)	22	24	(g)			25	24.6
Pr	10.2	(a)									
Nd	47.3	(a)	47.5	(f)	8.5	15	(g)			16	15.5
Sm	13.5	(a)	13.4	(f)	3	3.9	(g)			4.28	4.4
Eu	1.85	(a)	1.84	(f)	0.98	1.01	(g)			1.12	1.03
Gd	14.9	(a)	16.4	(f)							5.21
Tb	2.64	(a)			0.74	0.92	(g)			1	
Dy	16.6	(a)	17.2	(f)							6.64
Ho	3.59	(a)									
Er	10.2	(a)	10	(f)							4.57
Tm											
Yb	9.2	(a)	9.53	(f)	3.9	4.4	(g)			4.5	4.88
Lu	1.33	(a)	1.5	(f)	0.59	0.68	(g)			0.67	0.592
Hf	10.2	(a)	10.8	(f)	3.5	3.5	(g)			3.4	
Ta	1.48	(a)			0.34	0.4	(g)			0.38	
W ppb	0.71	(a)									
Re ppb	1.48	(b)						0.781	(h)		
Os ppb											
Ir ppb	15.8	(b)			0.25	0.0084	(g)	8.89	(h)	0.0029	
Pt ppb	33.8	(b)									
Au ppb					0.026	0.088	(g)	5.09	(h)	0.056	
Th ppm	5.36	(a)			1.57	1.8	(g)			2	
U ppm	1.39	(a)			0.5	0.58	(g)	1.45	(h)	0.59	
technique	*(a) ICP-MS, (b) ICP-ID-MS, (c) INAA, (d) elec. Probe, (e) AA, (f) IDMS, (g) INAA, (h) RNAA, (I) colorimetry*										

Table 2. Composition of 77075

		U ppm	Th ppm	K20 %	Rb ppm	Sr ppm	Nd ppm	Sm ppm	technique
Nunes et al. 1974	dark dike	1.425	5.299						IDMS
Nakamura and Tats 1977	dark dike			0.1937	5.927	161.7	49	14.1	IDMS
Winzer et al. 1974	dark dike			0.23	6.1		47.5	13.4	IDMS
Norman et al. 2002	dike	1.39	5.36	0.24	8.9	183	47.3	13.5	ICP-MS
Warren and Wasson 1978	w. norite	0.5	1.57	0.18			8.5	3	INAA
Warren and Wasson 1978	w. norite	0.58	1.8	0.16			15	3.9	INAA